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WATER SAMPLING FROM FIXED WING AIRCRAFT

Charles W. Ferst, et al

Federal Water Pollution Control Administration
Charlottesville, Virginia

August 1969

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Water Sampling from Fixed Wing Aircraft

by

Charles W. Forst

R. Kenneth Tinsley

August 1969

Pollution Surveillance Branch
Middle Atlantic Region
Federal Water Pollution Control Administration
Charlottesville, Virginia

INTRODUCTION

On August 22, 1969, the Federal Water Pollution Control Administration Middle Atlantic Regional Office was advised that a pesticide formulation plant and warehouse at Massies Mill, Virginia, was destroyed by flood waters on August 20, 1969. Since it was not known whether the pesticides or other toxic materials had contaminated the river, samples were urgently needed during the initial flood period. Pollution Surveillance personnel met with representatives of All American Engineering Company, Wilmington, Delaware[1] in an effort to determine a safe method of sampling the flood-swollen James River. Several methods of sampling were considered. Boat sampling or sampling from a helicopter were unsafe. Many bridges were washed out and representative sampling locations were inaccessible. It was decided that samples would be taken utilizing an aerial pick-up technique generally used for air rescue operations.

The first successful, practical applications of water sampling techniques from a fixed wing aircraft took place on August 22 and August 23. The sampling runs covered a 200 mile span of the James River from Jamestown, Virginia, to Columbia, Virginia. Six samples were taken on each trip and were delivered to the laboratory within three hours from the time of take off. As a result of the new technique, Virginians living in the James River Basin were more assured

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1. Use of a company name does not constitute endorsement by the Federal Water Pollution Control Administration.

that their municipal water supplies were safe, even during the worst part of the flood.

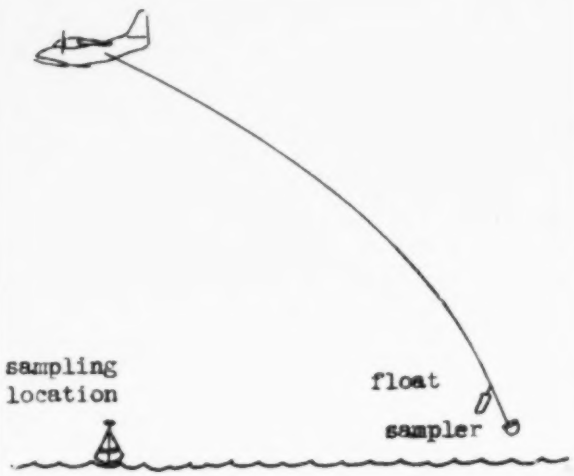
The James River flight illustrated a practical method of water quality sampling of a large area of water in a short period of time at a relatively low cost, and has since generated considerable interest in the applicability of the method for water quality sampling in the future.

HISTORY

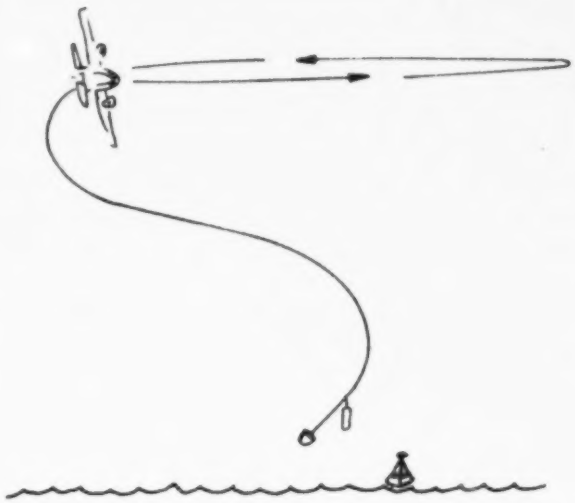
In 1934, an aerial recovery technique was introduced by A. V. Muzzy of Tyler, Texas. The "circling line" technique has since been modified and perfected by private and governmental organizations. Since A. V. Muzzy's demonstration, the "circling line" technique has been used in air rescue operations, emergency supplies delivery and pick-up, space program activities for nose cone and capsule recoveries, and various other missions. While the technique has been operational for several years, the limits of its usefulness have not been explored, particularly in the field of water sampling.

TECHNIQUE OF AERIAL WATER SAMPLING (See Figure I)

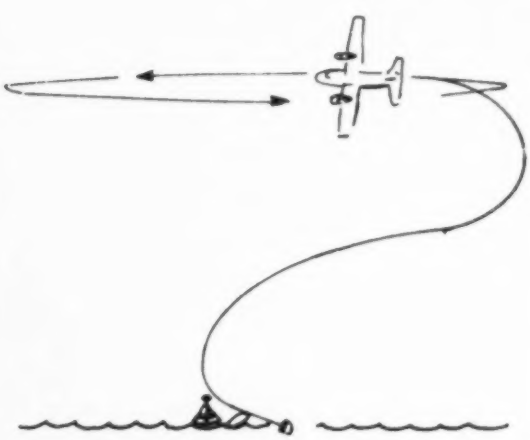
The sampling point, usually predetermined and designated by latitude and longitude, is located by aeronautical navigation methods. Buoys may also be used to mark permanent sampling stations and can be installed and removed from the aircraft. As the airplane approaches



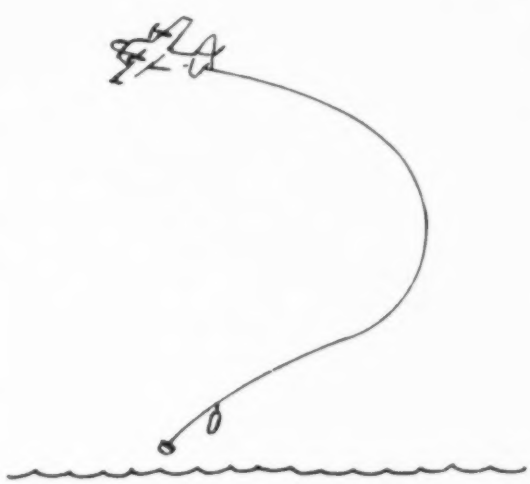
Airplane passes over desired sampling point in water and lowers line with sampler and float



Airplane begins to circle, causing sample container to move to center of circle



Airplane modifies its circle and descends so that float rests on water and sampler is submerged



When sampler is full, airplane begins climbing turn and raises sample from water to be reeled into airplane

FIGURE I

the desired sampling site, a long line with the sampler at the end, is trailed behind the airplane. A float is attached to the line above the sampler to control the depth at which the sample is to be taken. Several sample containers can be attached to the line at various depths in the case of bay or estuary sampling where profiles are desired. The airplane enters a circle as tight as the airplane can consistently maintain (the radius of the circle is dependent on the type of aircraft - see Figure II) above the sampling point. Under the combined action of the weight, lift, and drag of the line, the lower end of the line "finds" the center of the circle and remains almost motionless with respect to the ground. When the line is fully unwound (the length of the unwound line varies from 1000 feet to 9000 feet depending upon the type of aircraft, airspeed, radius of the circle, type of line used, and weight of sampler), the airplane descends until the float rests on the surface of the water and the sample container is submerged. The airplane continues to circle until the sampler is filled. (The aircraft may circle as long a period of time as is required to fill the sample container.) When the sampler is filled the airplane pulls out of the circle and starts for the next sampling point. The sample is pulled into the airplane by an electric winch and is labeled and stored by standard sample handling procedures.

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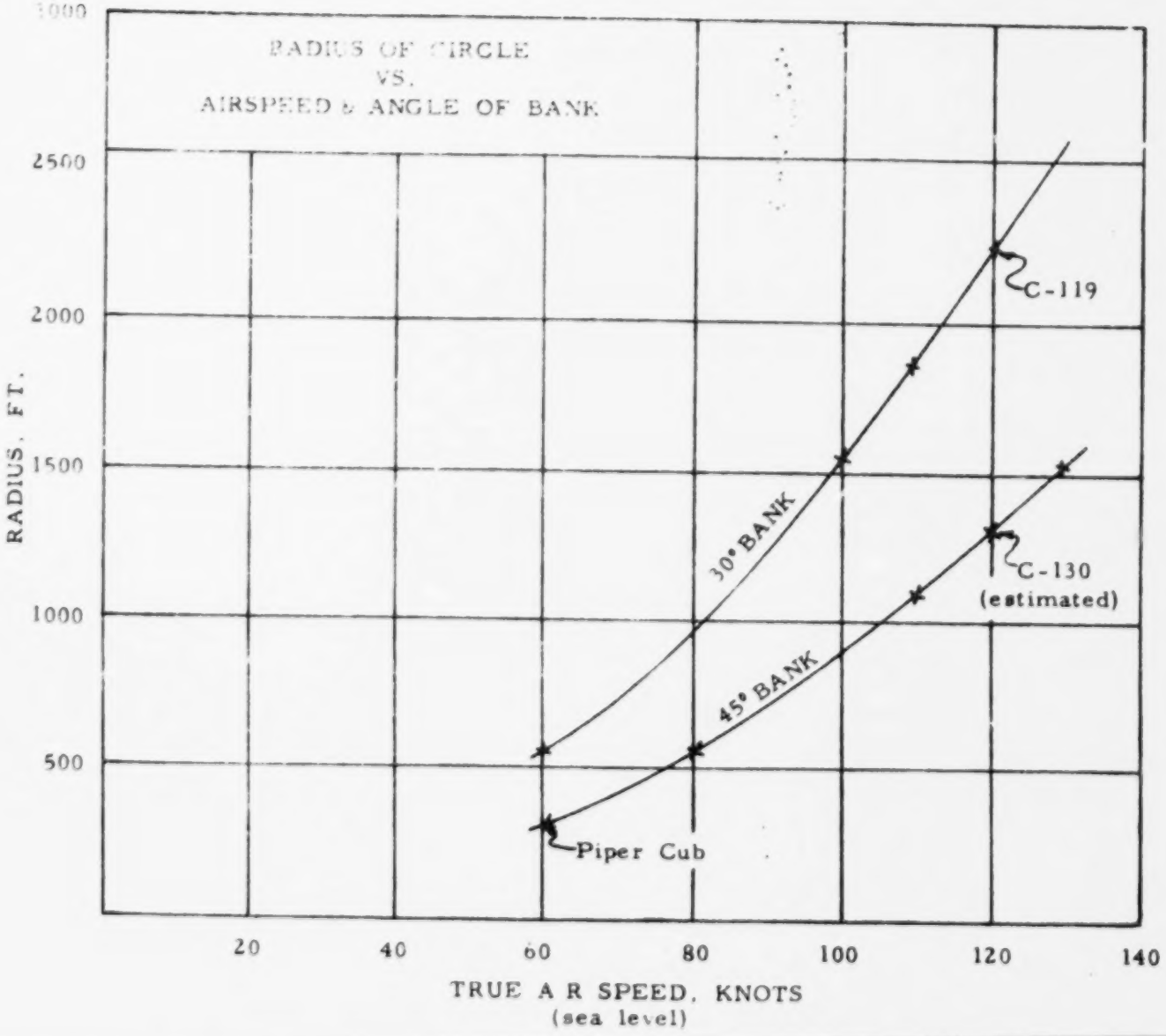
RADIUS OF CIRCLE
VS.
AIRSPEED & ANGLE OF BANK
3000
2500
2000
1500
1000
500
RADIUS, FT.
30° BANK
45° BANK
C-119
C-130
(estimated)
Piper Cub
20
40
60
80
100
120
140
TRUE A R SPEED, KNOTS
(sea level)

FIGURE 11

It is possible to place the sampler within 5 - 30 feet (depending on natural conditions, e.g., wind, weather, terrain) of the orginally planned sampling location. The period of time it takes to complete one sampling operation again depends on several conditions. Generally, however, the time period including identifying and locating the point, entering and maintaining the circle, dropping the container and retrieving the sample, handling the sample and reentering normal flight is approximately 5 - 10 minutes.

APPARATUS

The sample container should be made of a heavy, nonbreakable material. It should be weighted at one end to overcome buoyant effects and to stabilize the container so that it will fill at a faster rate. There is no specified opening size at the top. However, if the opening is too large, the sample will be lost due to spinning and wind effects before it can be retrieved. It is recommended that the opening be no larger than three inches in diameter and no smaller than one half inch in diameter to insure rapid filling. The shape, size, and weight of the container are only defined by size and weight capacities of the particular aircraft and winch used. A two liter "sergeant" sampler, with a one half inch opening, was used effectively on the James River sampling run.

A winch suitably designed for the "circling line" should have a reeling rate of 1000 to 2000 feet per minute to reduce time on station.

It is desirable that it be able to maintain constant tension on the line. The best wat to retrieve the sample container from the water is by applying a constant tension matched to the maximum reasonable velocity (and the resulting drag) of the object in the water. Such a condition will produce a satisfactory emergence rate without producing excessive line loads which occur with little or no warning due to the high density of water. A constant tension winch allows additional maneuverability in the flight path due to winds, gusts, or flight errors without overstressing the line. The winch must be compact and light. Winch size depends on drum storage space or line required and the diameter of the line. For example, a winch to store 9000 feet of $\frac{1}{4}$ inch line requires $4\frac{1}{2}$ cubic feet of drum storage space. The Pick-up winch used during the sampling run on August 22 has a reel in rate of 150 ft/min for a 300 pound load. The entire winch occupies approximately eight cubic feet and its drum storage space is approximately $2\frac{1}{2}$ cubic feet.

The type of line used is an important aspect of the "circling line" technique. Steel line should be avoided since it is almost invisible and, therefore, dangerous to personnel on the ground. Also, due to its high strength, the relatively small diameter of the steel cable would not develop much lift or drag. A line having a larger diameter and less rigidity will cause enough lift and drag to put a "bow" in the line which will absorb shock and tend to hold the end of the line more nearly in the center of the circle.

A trailing line consisting of quarter-inch diameter nylon line 1500 feet long was prepared for the James River flight. With the "sergeant" sampler attached (approximately 5 pounds) the line proved to be very effective in producing the circling line effect.

Several types and varieties of aircraft may be employed to take water samples. However, a winch must be installed and there must remain adequate space for sampling operations. The modified C-206 is ideal for aerial sampling as was illustrated on the James River flight.

THE SAMPLING CREW

Two men can perform the aerial sampling operation adequately; however, a three man team is more desirable. An experienced pilot makes up the most important part of the crew as the "circling line" technique requires considerable skill in operating the aircraft. An engineering technician is responsible for the operation of the winch and handling of the sample. The third man (optional), preferably a man trained in water quality control work, supervises the activities and assists the pilot and technician in performing the sampling operations.

COSTS OF AERIAL SAMPLING

The following tables and illustrations relate some of the advantages of using aerial sampling techniques, including the economic

advantage. All costs were estimated and are not standard figures. Aerial sampling costs are for fixed wing aircraft only.

A Comparison of the James River Costs as Opposed to Costs Encountered During Routine Sampling by Conventional Methods

METHOD	APPROX. TIME PERIOD TO MAKE RUN	NUMBER OF STATIONS	NUMBER OF SAMPLES PER STATION	CREW	APPROX. AVERAGE COST PER STATION*
Aerial Monitoring	1 day	12	1	3 men	$75.00-$100.00
Stream, lake or estuary sampling from a boat	5 - 8 days	12	1	2 - 4 men	$65.00-$120.00

*Costs vary as distance between sampling points and quantity of sampling points vary

The following hypothetical illustrations are examples of how aerial sampling could best be applied.

I. Estuaries between two points are to be sampled by two sampling crews. Crew Number 1 will travel across land and sample each estuary by boat. Crew Number 2 will utilize aerial sampling techniques. The following table compares the two methods.

CREW	TOTAL DISTANCE COVERED	NUMBER OF STATIONS	AVERAGE DISTANCE BETWEEN STATIONS	APPROXIMATE TIME TO COMPLETE RUN	ESTIMATED COST PER STATION*
Number 1	900 miles	30	30 miles	15 - 20 days	$110.00-$130.00
Number 2	900 miles	30	30 miles	1½ - 2½ days	$ 80.00-$ 90.00

*Costs are variable and may be affected by weather, season of the year, terrain and many other unique problems usually encountered

II. A bay has boundaries 50 miles by 200 miles. It is to be sampled near recreational areas, shellfish areas, known problem areas and at the mouth of all major rivers. It will be sampled by aerial techniques and conventional methods. It is desirable to run to all the stations in one day, which will require five boat crews or one aerial sampling crew. The following is a comparison of the two methods.

METHOD	TOTAL DISTANCE COVERED	NUMBER OF STATIONS	AVERAGE DISTANCE BETWEEN STATIONS	APPROXIMATE TIME TO COMPLETE RUN	ESTIMATED COST PER STATION*
Boat Sampling	300 miles	40	10 miles	1 day per crew	$ 50.00-$ 75.00
Aerial Sampling	300 miles	40	10 miles	1 day	$ 30.00-$ 40.00

*Costs are variable and may be affected by weather, season of the year, terrain and many other unique problems usually encountered

APPLICABILITY TO WATER QUALITY SAMPLING ACTIVITIES

The best application of the aerial sampling technique would be on routine sampling of estuaries, lakes or other large bodies of water. Aerial sampling can also be used in emergencies where access by most vehicles is limited, such as the James River flood. Samples can be delivered to the laboratory within hours after an incident. For this reason alone, aerial sampling may prove to be invaluable in the future.

The technique does not, however, lend itself to routine stream sampling. There is a danger of tangling the line in trees. Most streams are too narrow and/or shallow (water body should be at least four feet deep and approximately 100 feet wide for effective use of the technique).

Aerial sampling may become an important part of any overall water quality sampling program and certainly will be considered a unique tool.

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